Falling Flexible Sheets

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Abstract

We present a fluid dynamics video showing simulations of flexible bodies falling in an inviscid fluid. Vortex sheets are shed from the trailing edges of the bodies according to the Kutta condition. The basic behavior is a repeated series of accelerations to a critical speed at which the sheet buckles, and rapidly decelerates, shedding large vortices. Examples of persistent circling, quasi-periodic flapping, and more complex trajectories are shown.

The video is shown in high-resolution and low-resolution files.

The first clip is entitled "**Falling flexible sheet trajectories: Example of buckling while falling**." The moving solid orange line is a flexible fiber, falling under gravity, and shedding a vortex sheet (blue line) from its trailing edge. The two control parameters are the sheet density normalized by fluid density (R_1, 0.3 here) and the sheet rigidity normalized by fluid inertia (R_2, 2.4 here). The basic behavior is a repeated series of accelerations to a critical speed at which the sheet buckles, and rapidly decelerates, shedding large vortices. The still frames which surround the moving picture give sample trajectories for many different initial falling angles and different sheet rigidities. These paths show a diversity of punctuated falling and circling behaviors (circling is seen for R_2 equal to 10 and above). The still frame labeled "$R_1 = 0.3$, $R_2 = 2.4$" shows in light blue the trajectory traced by the orange fiber as it falls.

The second clip, "**Falling flexible sheet trajectories: Examples of quasi-periodic flapping**," shows an alternative falling behavior. For a range of smaller R_1 and R_2 (two examples are shown), the body flaps steadily as it falls. The example to the left is an asymmetric flapping state.

The example to the right shows symmetric flapping with a simple period. The drag encountered by these flapping bodies balances the acceleration from gravity. The still panels again show examples of different falling trajectories as parameters are varied. The blue trajectories in the still frame labeled "$R_1 = 0.3$, $R_2 = 1$"correspond to states of flapping while falling, encountered for many different initial falling angles.